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TECHNICAL MANUSCRIPT 478

THE EFFECTS OF CACODYLIC ACID ON THE
TRANSLOCATION OF 2,4-D IN BEAN PLANTS

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ABSTRACT

The effect of cacodylic acid on the translocation of 2,4-D was studied by droplet applications to bean leaves. Responses were studied by utilizing plant weights and by autoradiography. Cacodylic acid was antagonistic to 2,4-D toxicity when applied as a mixture. The antagonism was reduced when the two compounds were applied as separate droplets. The antagonism of cacodylic acid to 2,4-D toxicity was due to both a reduction in absorption and translocation of the systemic herbicide.

I. INTRODUCTION

In field spraying operations, frequently it is desired to combine the phytotoxicity of two or more herbicides in a single spray mixture. However, a lack of information in the literature concerning possible interactions between the herbicides in mixtures makes laboratory studies imperative.

Although the literature is not extensive, some investigators have conducted experiments concerning such synergistic or antagonistic interactions. Sargent and Blackman¹ demonstrated that TIBA (2,3,5-triiodobenzoic acid) inhibited the penetration of 2,4-D into Phaseolus leaf discs. A 72-hour pretreatment with amitrole increased the translocation of paraquat-C¹⁴ in quack grass.² In these same studies, however, amitrole was antagonistic to the absorption of paraquat-C¹⁴ when the two herbicides were applied simultaneously. Ammonium thiocyanate increased the translocation of amitrole-C¹⁴.³ Crafts and Yamaguchi⁴ showed that pretreatment with 2,4-D inhibited the translocation of amitrole-C¹⁴ in Zebrina.

Several papers have been published on the field responses to herbicide mixtures.⁵⁻⁸

The studies reported here were conducted to determine the effects of a desiccant, cacodylic acid (dimethylarsinic acid), on the absorption and translocation of a systemic herbicide, 2,4-dichlorophenoxyacetic acid. In this work, the objective was to determine the effect of rapid tissue kill at the application site on the absorption and translocation of the systemic herbicide.

II. MATERIALS AND METHODS

A. GENERAL

The experimental plant for these studies was 14-day-old Red Kidney bean (Phaseolus vulgaris var. Red Kidney) grown and treated under greenhouse conditions. This plant was chosen because of easy availability and rapid symptom development.

Cacodylic acid was studied as the pure acid and as the sodium salt from the formulation Phytar 560G. 2,4-D was studied as the ammonium salt, triethanolamine salt, and C¹⁴-labeled pure acid. All chemicals were applied in a 0.5% Tween 20 aqueous solution. The microgram quantity of 2,4-D used in all studies was chosen to provide a borderline lethal rate when applied alone.

A completely randomized design was used for all studies. Unless otherwise stated, each treatment was replicated 10 times.

Each treatment solution was applied in a semicircle of 10- μ liter drops near the basal end of each primary leaf. When chemicals were combined in a single solution, five 10- μ liter drops were applied over veins on each primary leaf, or a total volume of 100 μ liters per plant. When two chemicals were applied in separate solutions, the systemic was applied as five 10- μ liter drops over veins while the desiccant was applied as five 10- μ liter drops between the veins.

Plants were harvested 14 days after treatment. Fresh and dry weights were determined at the time of harvest. Weight measurements were analyzed by Duncan's Multiple Range Test.

B. INITIAL STUDIES

Initial studies were made to determine the effects of cacodylic acid on the activity of 2,4-D when the two herbicides were applied in a mixture. Cacodylic acid (sodium salt) was used at 200 μ g per plant while 2,4-D (ammonium salt) was applied at 600 μ g per plant. The chemicals were applied in a mixture as five 10- μ liter droplets per primary leaf with each droplet being applied over a vein.

After initial results were obtained, the chemicals were tested in separate drops to the leaves. In these studies, 2,4-D (ammonium salt) at 800 μ g per plant and cacodylic acid (sodium salt) at either 200 or 400 μ g per plant were applied: (i) to separate plants; (ii) to the same plants in a mixed solution; and (iii) to the same plants but in separate droplets of separate solutions.

C. RATE STUDIES

To determine the effects of different rates of cacodylic acid on the translocation of 2,4-D, cacodylic acid (sodium salt) was applied at 50, 100, 200, 300, or 400 μ g per plant, while 2,4-D (triethanolamine salt) was held constant at 600 μ g per plant. The chemicals in these studies were applied as mixtures to the five major veins of each primary leaf.

D. ISOTOPE STUDIES

Isotope studies of the effects of cacodylic acid on the translocation of labeled 2,4-D were undertaken. For these studies C^{14} -ring-labeled 2,4-D acid with a specific activity of 0.02 millicurie per millimole was used. The pure acid form of cacodylic acid was used in the isotope studies. Due to the low solubility of 2,4-D acid in water, chemical treatments were applied in a 50% ethanol solution that contained 0.5% Tween 20. Cacodylic

acid was applied at 200 µg per plant while 2,4-D was used at 505 µg per plant with an isotope activity of 0.05 µc. Treatment application techniques were the same as those outlined for the separate droplet experiment explained above. Four replications were used in the isotope studies.

Isotope applications were made to 14-day-old Black Valentine beans growing in half-strength Hoagland's solution. Black Valentine beans were chosen for these experiments because of their long internodes that facilitate autoradiography. These studies were conducted in an Isco growth chamber with the following environmental conditions: day length, 16 hours; temperature, 25 ± 0.5 C; relative humidity, $60 \pm 2\%$; and light intensity, 1,400 foot candles. Plants were harvested 5 days after treatment and freeze-dried. After freeze drying for 2 weeks, the plants were mounted and exposed to Royal Blue X-ray film for 6 weeks, and the films were then developed.

E. ABSORPTION STUDIES

Absorption studies were initiated to determine whether the effect of cacodylic acid on the phytotoxicity of 2,4-D was due to inhibition of absorption or to inhibition of translocation. The two herbicides were applied to the same veins at various time intervals. Applications of 2,4-D (triethanolamine salt) were made distally to the cacodylic acid (sodium salt) droplets, separated by a distance of approximately 1/3 inch. Six hundred micrograms of 2,4-D were applied at 0, 2, 4, 6, or 24 hours after application of 200 µg cacodylic acid to the primary leaves. Each chemical was applied as five 10-µliter drops to major veins of each primary leaf. By applying the two compounds in this manner, the absorption of 2,4-D was not inhibited but the translocation mechanism might have been blocked.

III. RESULTS AND DISCUSSION

A. INITIAL STUDIES

Initial studies indicated that cacodylic acid was antagonistic to and reduced the phytotoxicity of 2,4-D when the two materials were applied in a mixture. Preliminary results on the antagonism between the two chemicals were reported by Truchelut, Martin, and Hart.⁹

In the separate droplet studies, plants treated with a mixture of cacodylic acid and 2,4-D made significantly greater growth in weight compared with plants treated with 2,4-D alone (Table 1). The results as well as data from the initial studies suggested interference by cacodylic acid with the absorption and translocation of 2,4-D. Plants treated with separate drops of the two chemicals showed no significant difference in growth from the 2,4-D treated plants, even though the droplets of the two solutions were fairly close together on the leaf.

TABLE 1. EFFECTS OF CACODYLIC ACID ON PLANT RESPONSE
TO 2,4-D AMMONIUM SALT

Treatment	Dry Weight, ^a / % of Control
Control	100.0 ^a
800 µg 2,4-D	22.6 ^c
200 µg cacodylic acid	79.8 ^b
400 µg cacodylic acid	83.1 ^{a, b}
Mixtures of 800 µg 2,4-D plus: 200 µg cacodylic acid	73.1 ^b
400 µg cacodylic acid	64.7 ^b
Separate spot applications of 800 µg 2,4-D plus:	
200 µg cacodylic acid	42.0 ^c
400 µg cacodylic acid	41.1 ^c

a. Averages followed by the same superscript letter are not significantly different at the 5% level (Duncan's Multiple Range Test).

B. RATE STUDIES

Cacodylic acid at rates above 100 µg per plant caused a significant reduction in response to 2,4-D when the two chemicals were applied as a mixture (Fig. 1). Plants treated with the mixtures containing 50 or 100 µg of cacodylic acid did not differ significantly from plants treated with 2,4-D alone. The leveling off of the response curve at the 300- and 400-µg rates of cacodylic acid doubtless was due to the injurious effect of cacodylic acid at these high rates. Maximum antagonism between the two chemicals occurred at 200 µg of cacodylic acid, the lowest level causing complete leaf desiccation from droplet applications.

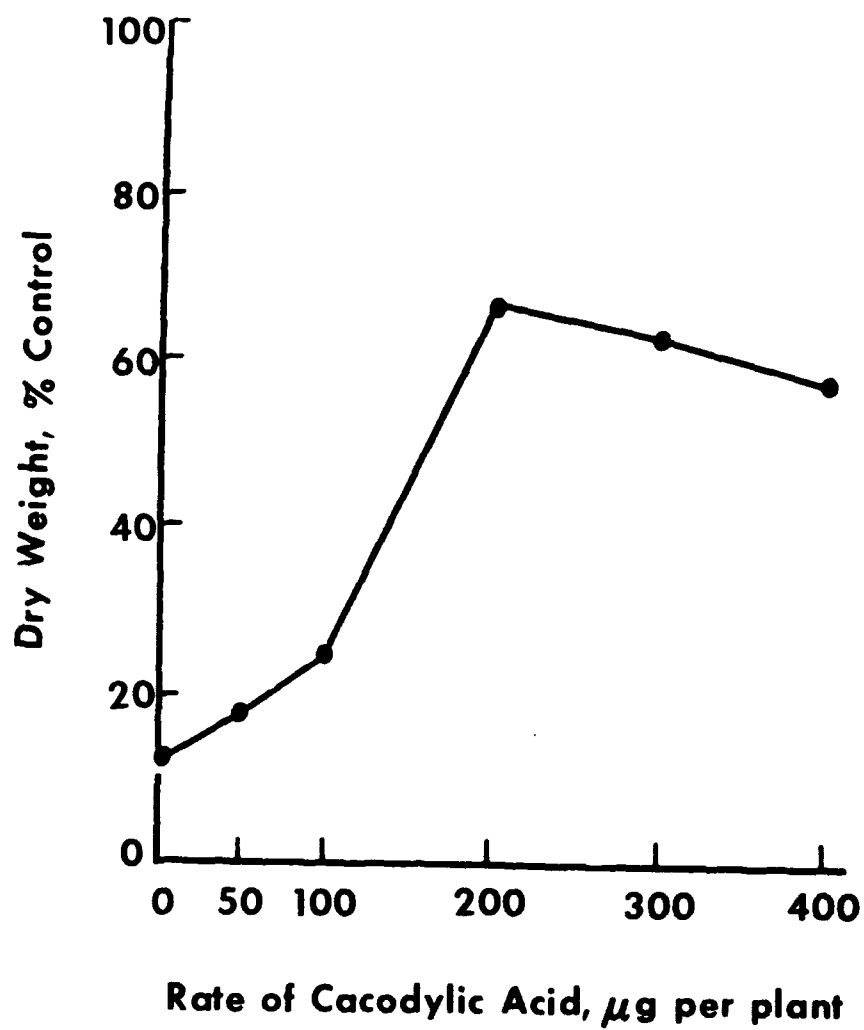


FIGURE 1. Effects of Different Rates of Cacodylic Acid on Response of Bean Plants to 600 μg 2,4-D Triethanolamine Salt When Applied as a Mixture.

C. ISOTOPE STUDIES

In the isotope studies, control plants produced a slight stem image on the film, believed to be caused by a pressure artifact. Plants treated with 2,4-D- Cl^{14} alone showed pronounced movement of the systemic both above and below the treated leaves, as shown by heavily labeled autoradiographs. When cacodylic acid was applied in a mixture with 2,4-D- Cl^{14} , there was a marked reduction in the movement of the systemic herbicide. When the two chemicals were placed in separate spots, considerable labeling occurred throughout the plant but this labeling was not as pronounced as that in plants treated with 2,4-D- Cl^{14} alone. Even in separate drops, it appears that cacodylic acid exerts some antagonistic effect on the movement of 2,4-D. From these studies it is evident that cacodylic acid interferes with the absorption and/or translocation of 2,4-D.

D. ABSORPTION STUDIES

When absorption is not interfered with, cacodylic acid and 2,4-D still exhibit marked antagonism (Fig. 2). This is evident from the antagonism that occurred when the droplets were applied simultaneously to the same veins. Plants treated simultaneously with the separate droplets showed a significant reduction in weight compared with plants treated with the mixtures. Yet these plants responded significantly less than plants treated with 2,4-D alone. There were no significant differences in plant response among the 0-, 2-, and 4-hour treatments. There was a significant difference in plant responses at the 6- and 24-hour treatment when compared with the 0-, 2-, and 4-hour treatments.

At the 6- and 24-hour treatments, the cacodylic acid had apparently killed the treated spots, thereby preventing the movement of 2,4-D. From these results, it can be concluded that cacodylic acid causes both a reduction of absorption and a reduction of translocation of 2,4-D.

IV. SUMMARY

The studies reported in this paper indicate that cacodylic acid is not compatible with 2,4-D when applied as a mixture. This effect is due to the fact that cacodylic acid kills tissue rapidly at the site of application, thus preventing the movement of 2,4-D from the point of treatment. Apparently, this antagonism is the result of both a reduction of absorption and a reduction in translocation. Less antagonism is shown between the two compounds when they are placed in separate spots on the leaves. Under laboratory conditions, it is therefore possible to obtain a fast leaf desiccation from a compound such as cacodylic acid and yet retain the long-term effectiveness of a systemic compound such as 2,4-D.

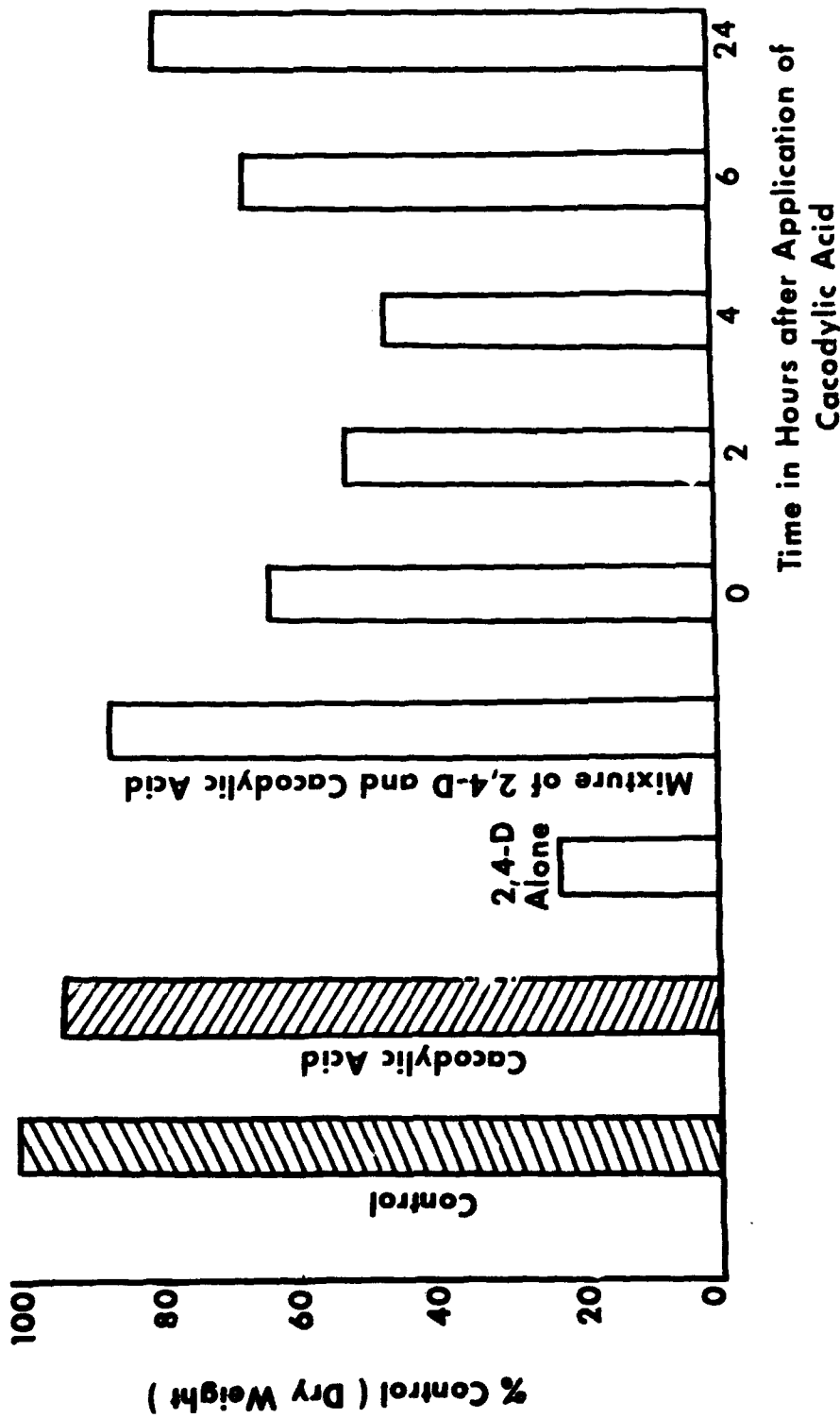


FIGURE 2. Effects of Cacodylic Acid on Activity of 2,4-D When Applied as Separate Droplets to the Same Veins and at Various Time Intervals.

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